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Estimating Growth of Young Mountain Whitethorn Shrubs

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Mountain whitethorn (*Ceanothus cordulatus*) is a major browse species in California, but information about its annual growth is scant. Regression equations have been developed to estimate current season growth of young shrubs based on shrub canopy area at the beginning ($r^2=0.82$) or at the end ($r^2=0.91$) of the growing season. Results are based on data collected in 1978, and so their use for years in which weather conditions differ substantially from those in 1978 could introduce an unknown amount of error.

Retrieval Terms: Ceanothus, biomass, California growth estimation, growth rate, brushfield

Mountain whitethorn (*Ceanothus cordulatus*) is one of the most abundant shrub species growing in the high-elevation brushfields of California. It is commonly found in open, sunny areas that have been logged or burned.[1] Brushfields made up of mountain whitethorn range from dense almost impenetrable stands to sparse open stands. Dense stands often inhibit conifer regeneration and temporarily reduce the growth rate of many conifer species, unless some form of site preparation is used.[2] Open stands provide forage and cover for many wildlife species. Mountain whitethorn is a major component of the diet of mule deer (*Odocoileus hemionus*) on summer range in the Sierra Nevada.[3,4]

An increase in growth and soil fertility has been reported with container-grown mountain whitethorn that developed nitrogen fixing root nodules.[5] Many species of *Ceanothus* have been reported to fix substantial amounts of nitrogen.[6] Nodules found on roots of mountain whitethorn are similar in appearance to those associated with other nitrogen fixing *Ceanothus* species.

The importance of mountain whitethorn as a browse species has been well documented and is currently an important consideration in land management. Prescribed burns are often used on the Sierra National Forest in northern California to encourage the establishment of mountain whitethorn.[7] Specific information about the annual growth of mountain whitethorn is scant.

This note describes regression equations for estimating the current season growth produced by young (1-5 years) mountain whitethorn shrubs based on shrub canopy area. Annual growth (kg/ha) of this species can be estimated by the equations if the number of shrubs per hectare and the size of shrubs are known.

STUDY LOCATION

Mountain whitethorn shrubs used in this study were selected on 10 recently logged and burned areas on the Bass Lake and Minarets ranger districts of the Sierra National Forest. The study areas represent typical young mountain whitethorn brushfields, ranging from open stands of dispersed plants to well

stocked, dense stands. Limited amounts (<5 pct. cover) of greenleaf manzanita (*Arctostaphylos patula*) and gooseberry (*Ribes* spp.) were also on these sites. The areas selected were sunny with open overstories and ranged in elevation from 1740 to 2250 meters.

METHODS

Young shrubs were selected to ensure that all of the current season leaders could be identified, for clipping, at the end of the growing season. The bud scale scar and lighter color of the current season leaders of young mountain whitethorn shrubs provide an accurate, quick method for identifying current season leaders. The leaders of older shrubs are difficult to identify because they lack this color difference.

At the beginning of the 1978 growing season (May-June), 40 mountain whitethorn shrubs were selected for study. The shrub canopy area and amount of current season growth produced during the season by each shrub was measured to establish the relationship between the two.

The mean diameter of each shrub was determined at the beginning and end of the growing season from four diameter measurements. These measurements were made across the center of the shrub at 45° intervals, starting from the north-south direction. The shrub canopy area (A) was calculated from the mean diameter (D) with the formula for the area of a circle ($A = \pi [D/2]^2$).

Current season growth was determined at the end of the growing season (late October) by clipping all new-growth twigs from each shrub. The new-growth twigs were clipped at the bud scale scar and oven-dried at 105° C for 24 hours. The twigs were allowed to cool in a desiccator and weighed to an accuracy of 0.1 g. The weight of the current season growth produced by each shrub was adjusted to account for moderate deer browsing of the new-growth twigs (2-15 pct.) that occurred during the growing season. This adjustment was made on the basis of an ocular estimate of the percent of the new growth browsed at the end of the growing season. In the analysis, 14 shrubs that had been heavily browsed (>40 pct.) by the end of the growing season were excluded. The age distribution of the shrubs used in this study was the following: 1 year (n = 5); 2 years (n = 4); 3 years (n = 7); 4 years (n = 8); 5 years (n = 2).

Each shrub was removed from the soil at the end of the growing season by cutting the trunk at the soil surface. This procedure made it easier to clip current season leaders and to determine the age of the shrub. After the shrubs were removed from the soil, the roots were examined to a depth of about 20 cm to determine if root nodules were present.

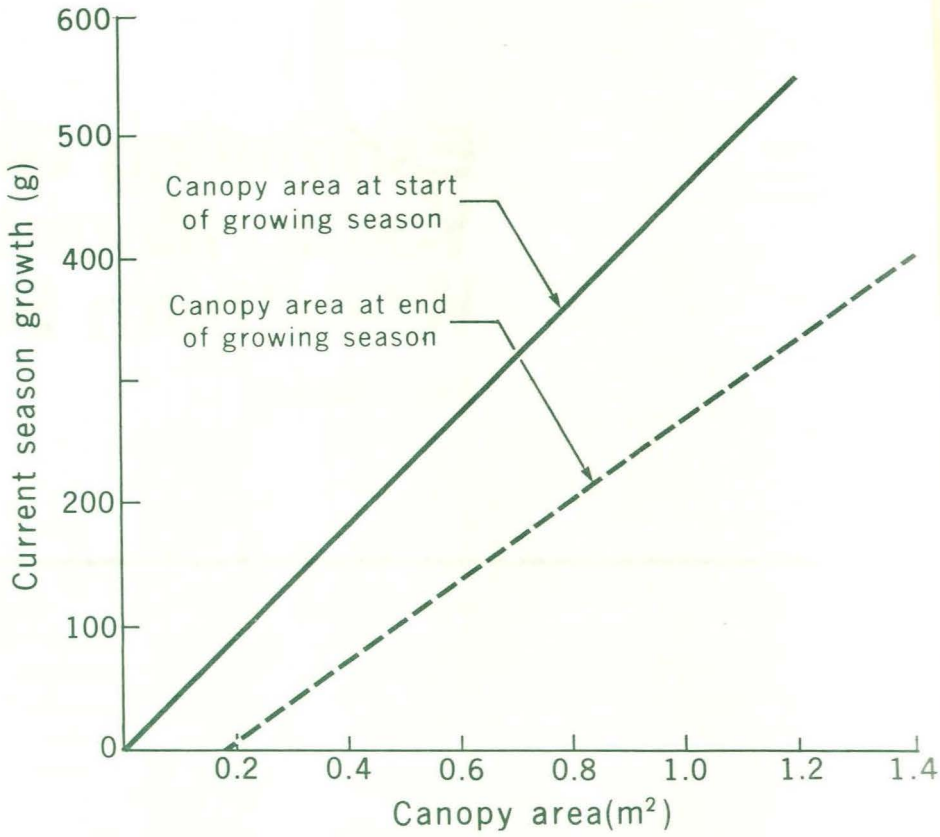

Figure 1-Relationship between canopy area and current season growth of mountain whitethorn shrubs based on 26 shrubs collected and analyzed in 1978.

RESULTS AND DISCUSSION

The following linear regression equation describes the relationship between canopy area at the beginning of the growing season and the amount of current season production by the end of the season:

$$\hat{Y} = -1.8 + 485.5\ X$$

in which $\hat{Y}$ is the estimated oven-dry weight in grams of current season growth and X is the the shrub canopy area in square meters at the beginning of the season (*fig. 1*). The standard error of the estimate is 77.5 g.

The following linear regression equation describes the relationship between canopy area at the end of the season and current season production:

$$\hat{Y} = -65.1 + 341.7\ X$$

in which $\hat{Y}$ is the estimated oven-dry weight in grams of current season growth and X is the the shrub canopy area in square meters at the end of the growing season (*fig. 1*). The standard error of the estimate is 56.6 g.

The canopy area at the beginning and end of the growing season explained 82

Table 1—*Estimated kg/ha production of mountain whitethorn shrubs based on diameter at start of growing season, by shrub densities and sizes*

Mean shrub diameter (m)	Canopy area (m^2)	Current season growth ± standard error (g)[1]	Estimated number of shrubs per hectare for given production[2]		
			1000 kg/ha	2000 kg/ha	3500 kg/ha
0.4	0.1257	59.2 ± 27.6	16,892 (21)	33,784 (42)	59,122 (74)
0.5	0.1963	93.5 ± 30.3	10,695 (21)	21,390 (42)	37,433 (73)
0.6	0.2827	135.5 ± 33.8	7,380 (21)	14,760 (42)	25,830 (73)
0.7	0.3848	185.0 ± 38.0	5,405 (21)	10,811 (42)	18,919 (73)
0.8	0.5027	242.3 ± 43.0	4,127 (21)	8,254 (41)	14,445 (73)
0.9	0.6362	307.1 ± 48.7	3,256 (21)	6,513 (41)	11,397 (73)
1.0	0.7854	379.5 ± 55.3	2,635 (21)	5,270 (41)	9,223 (72)
1.1	0.9503	459.6 ± 62.6	2,176 (21)	4,352 (41)	7,615 (72)
1.2	1.1310	547.3 ± 70.7	1,827 (21)	3,654 (41)	6,395 (72)

[1]As predicted by regression equation based on shrub canopy area at beginning of growing season.

[2]Values in parentheses are calculated canopy cover (percent) for brushfields of shrub density and size shown.

percent ($r^2 = 0.82$) and 91 percent ($r^2 = 0.91$), respectively, of the variation associated with the amount of current season growth produced during the 1978 growing season.

The smaller roots near the soil surface for all of the shrubs contained many root nodules. No attempt was made to count the number of nodules or determine the extent of their occurrence in the soil. The nodules had the same appearance as nitrogen-fixing nodules found in other species of *Ceanothus*.

The growth of mountain whitethorn for different densities and shrub sizes was computed according to the number of shrubs per hectare needed to produce a given weight (kg) per hectare of current season growth. The tabulated results (*table 1*) are based on data collected in 1978. Therefore, applying these results in years having substantially different weather conditions than those of 1978 could result in an unknown amount of error.

NOTES

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